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Study of the neutron damage on electronics at the National Ignition Facility

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November 7, 2010 through November 11, 2010

Disclaimer

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National Ignition Campaign

Study of the neutron damage on electronics at the National Ignition Facility

19th Topical Meeting on the Technology of Fusion Energy
November 10, 2010

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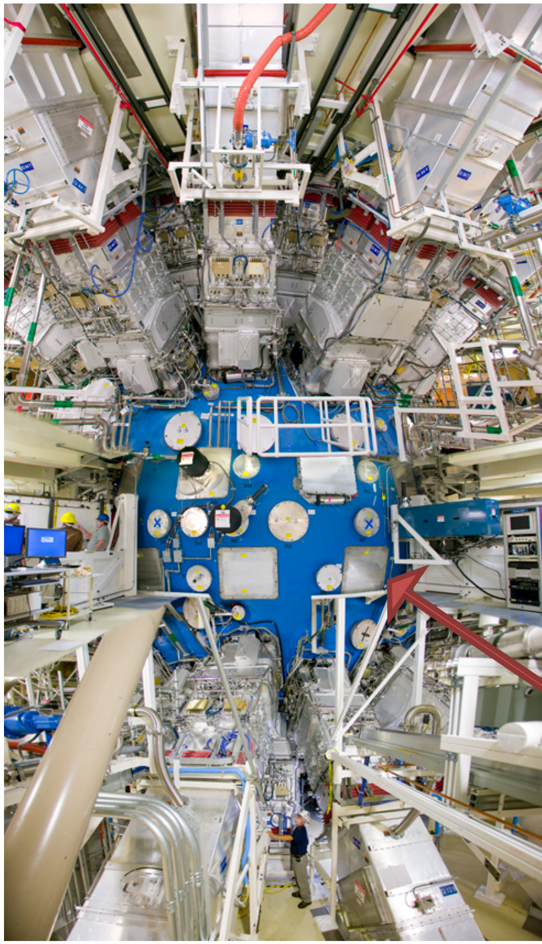
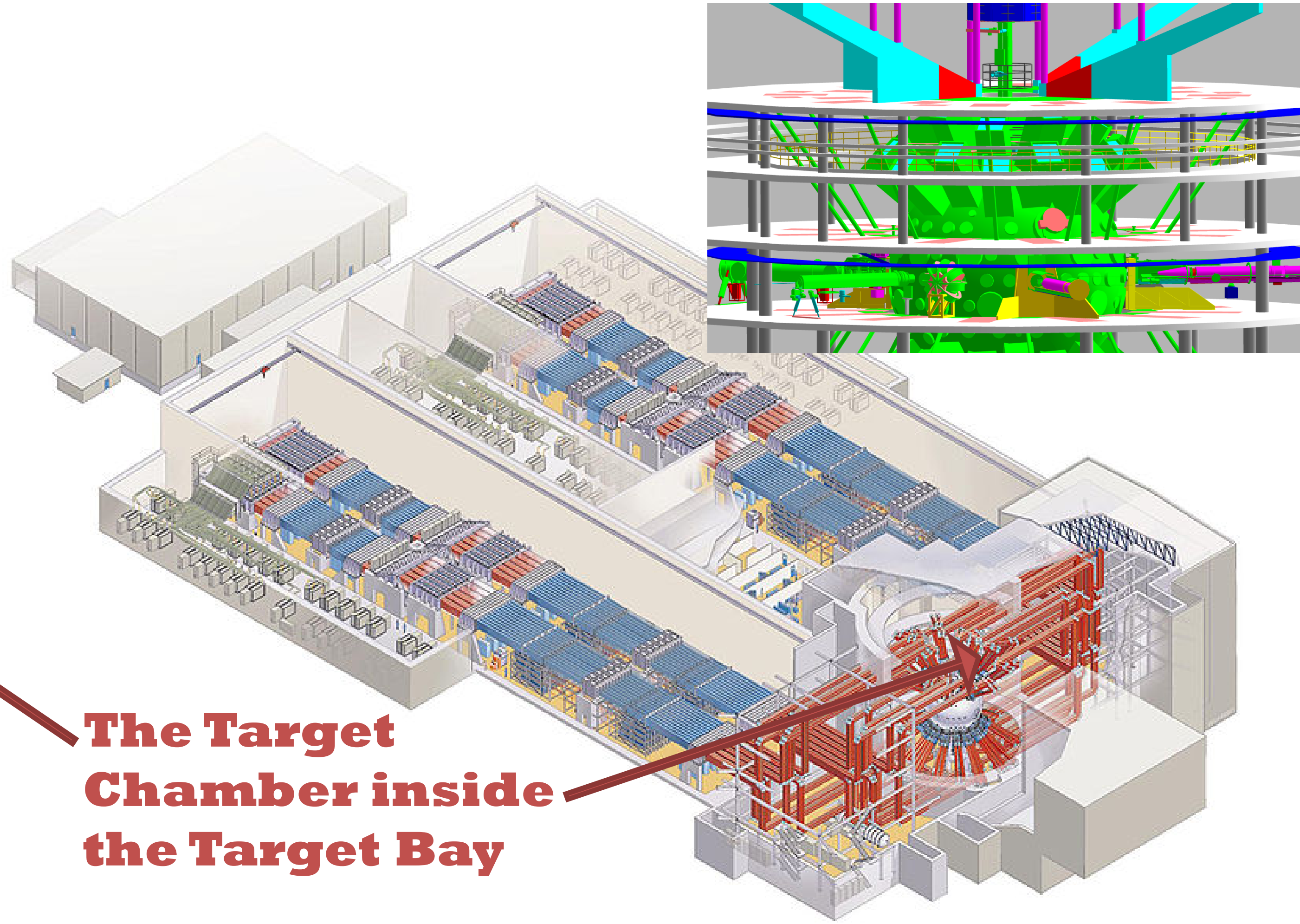
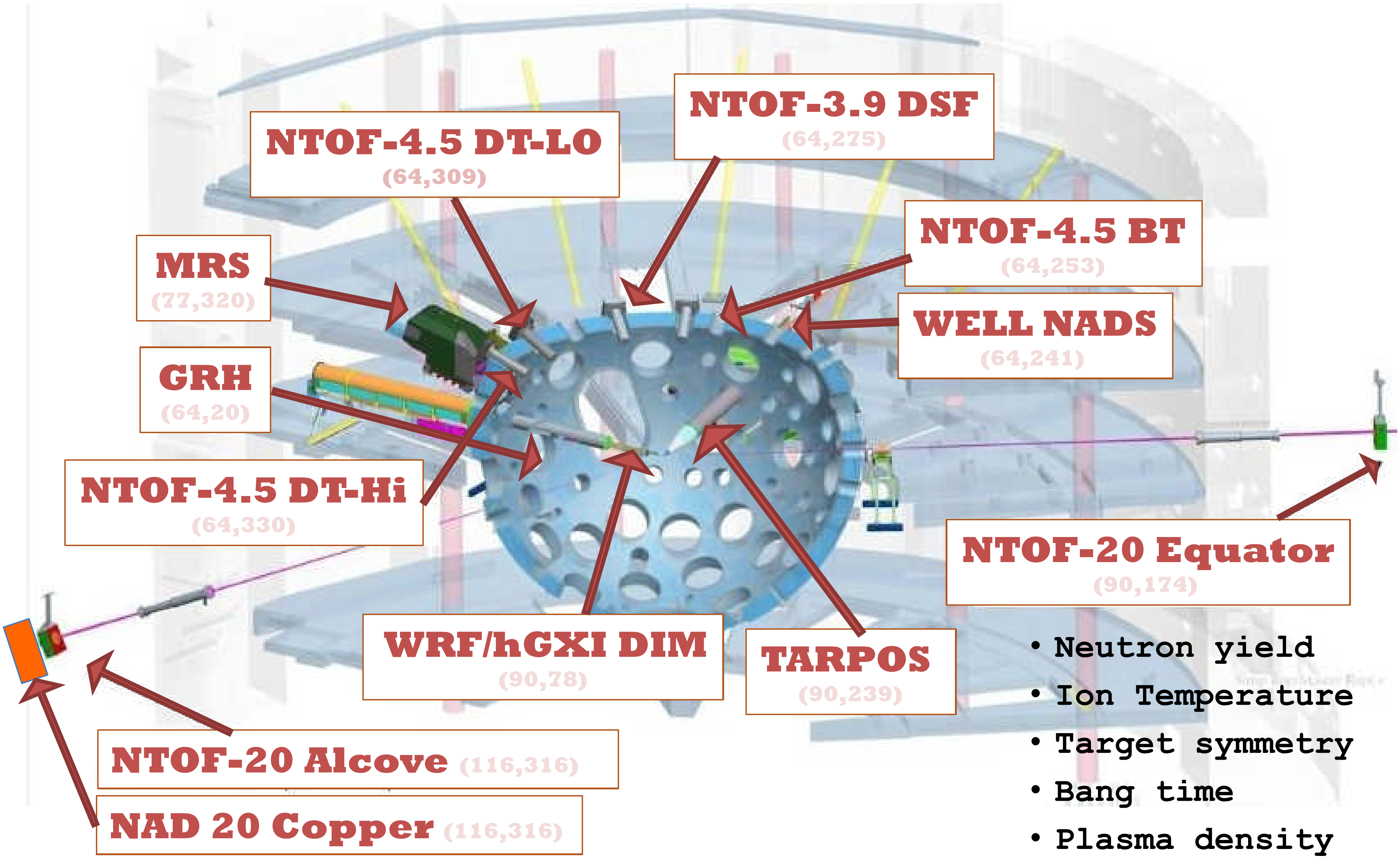
The National Ignition Facility





- The most powerful laser in the world
- 192 laser beams focus on a mm-size Deuterium Tritium target
- Goal: obtain ignition fusion
- How to monitor a shot: diagnostics

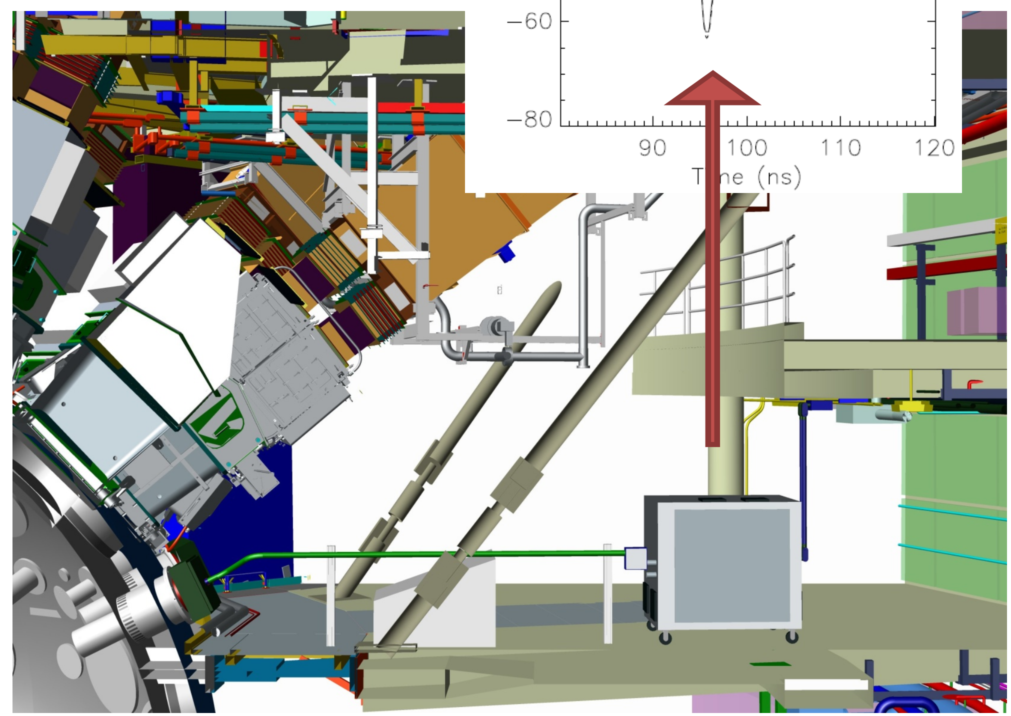
Nuclear Diagnostics to monitor a shot

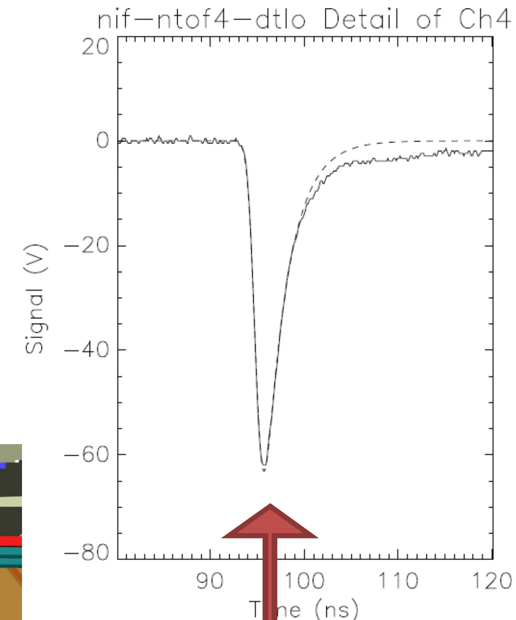


- Neutron yield
- Ion Temperature
- Target symmetry
- Bang time
- Plasma density

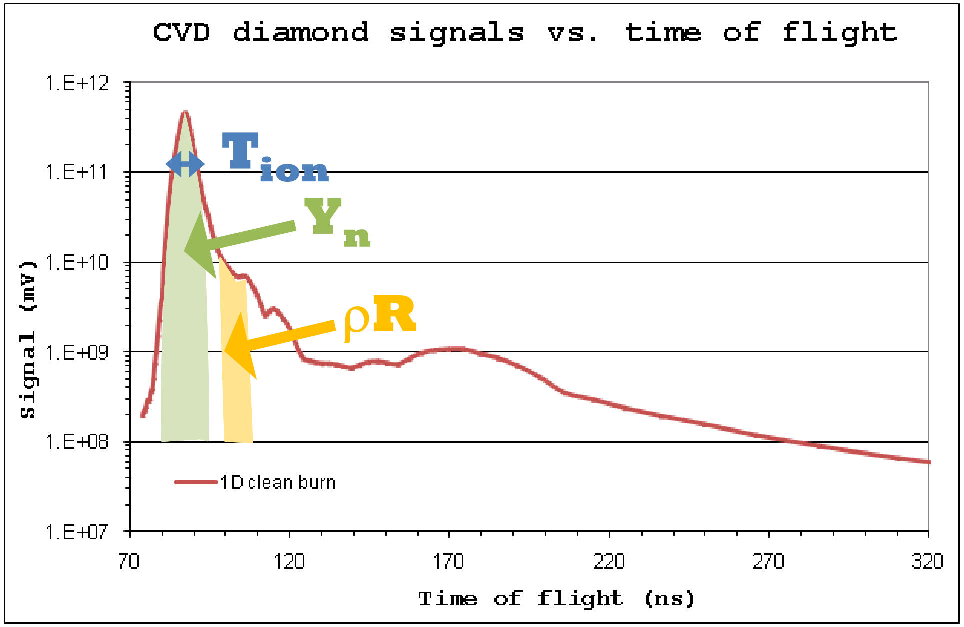
Neutron time-of-flight diagnostic at 4.5m from TCC

- Scintillators and CVD diamonds
- Will measure neutron yield & ion temperature
- May measure the areal density of the plasma
- Will be used for neutron yields up to 1e16

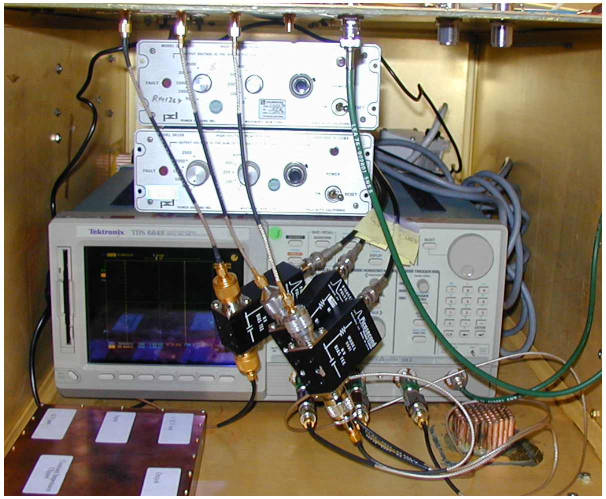




Neutron time-of-flight diagnostic

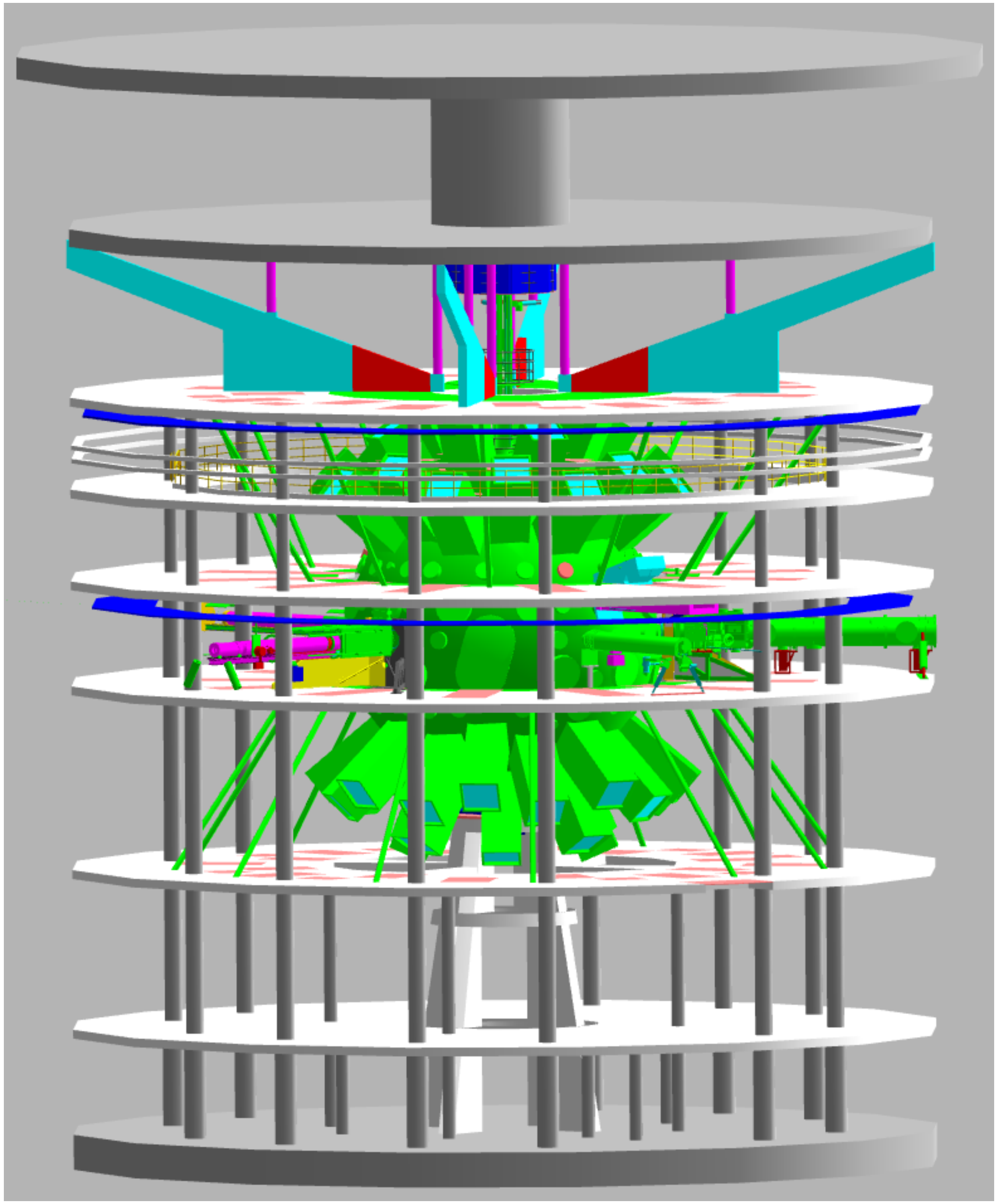


- Neutron yield (Y_n) α integral under the 14.1 MeV pulse
- Ion temperature (T_{ion}) α 14.1 MeV pulse width
- Plasma areal density (ρR) α integral under the 10-12 MeV signal

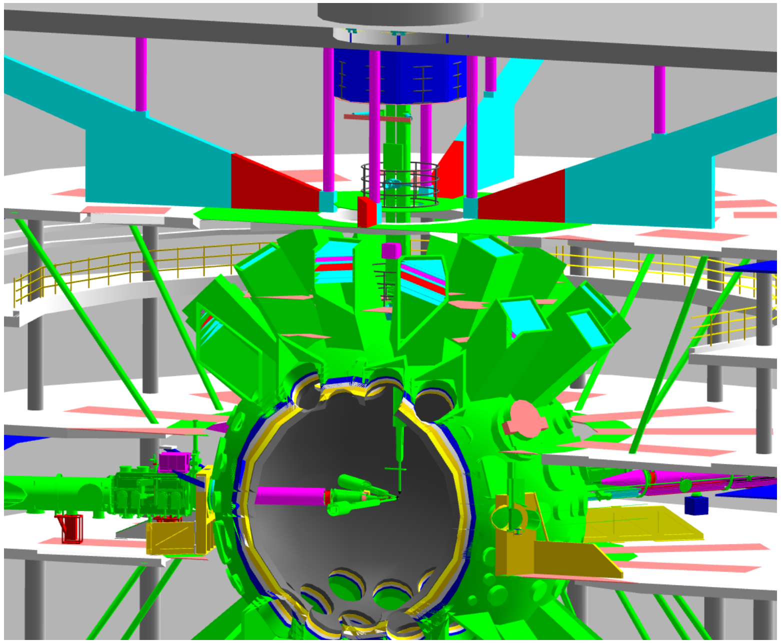


- Previous experience showed that damage starts at ≈ 1e7 n/cm^2
- Neutron Damage leads to:
  - Noise → added signal
  - Spikes
  - Stars
  - Loss of data or instrument

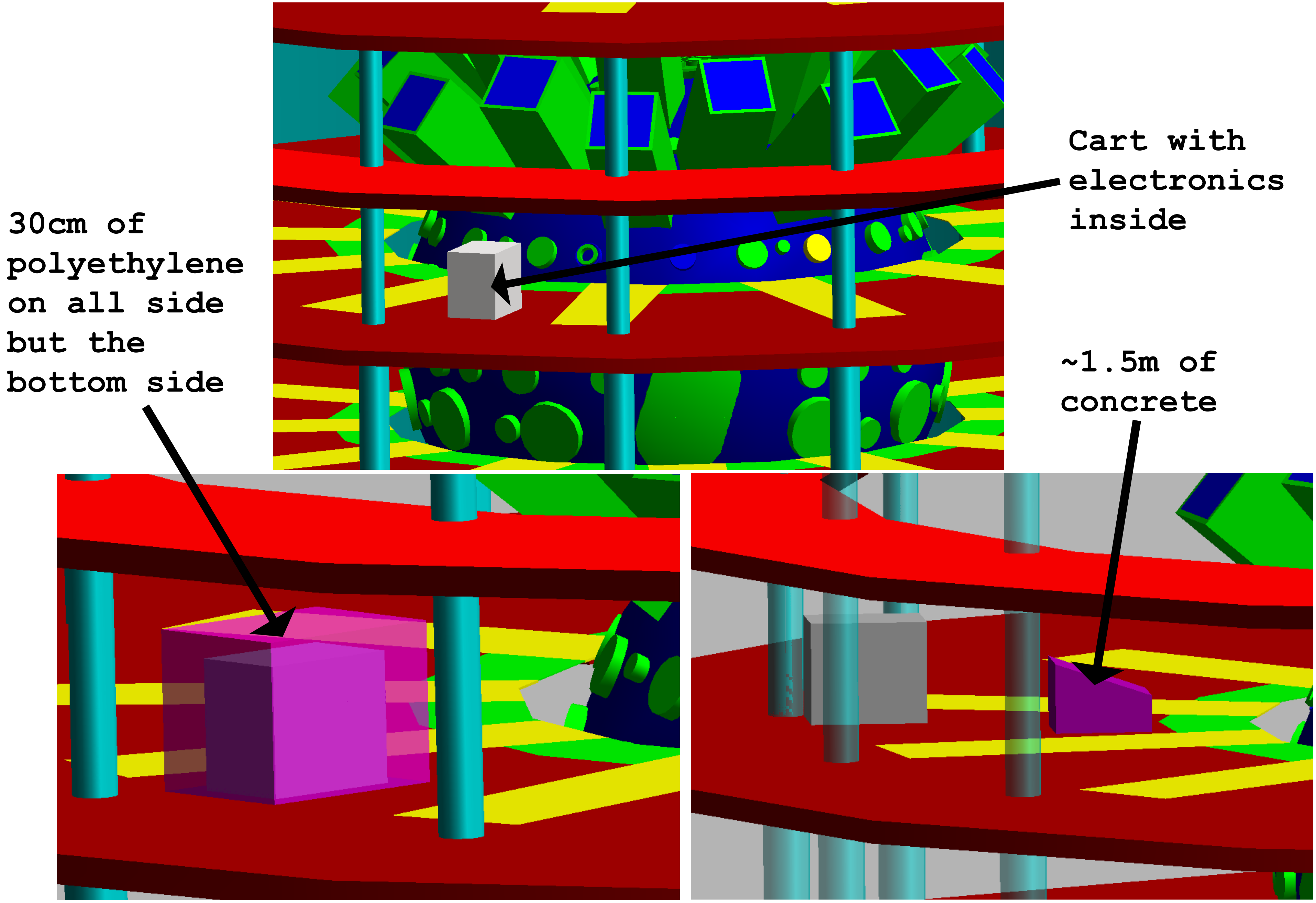
Simulation of the radiation background



- The Monte Carlo code MCNP was used
- Calculation of neutron and gamma fluxes per energy bin
- Use of different shields: concrete and polyethylene

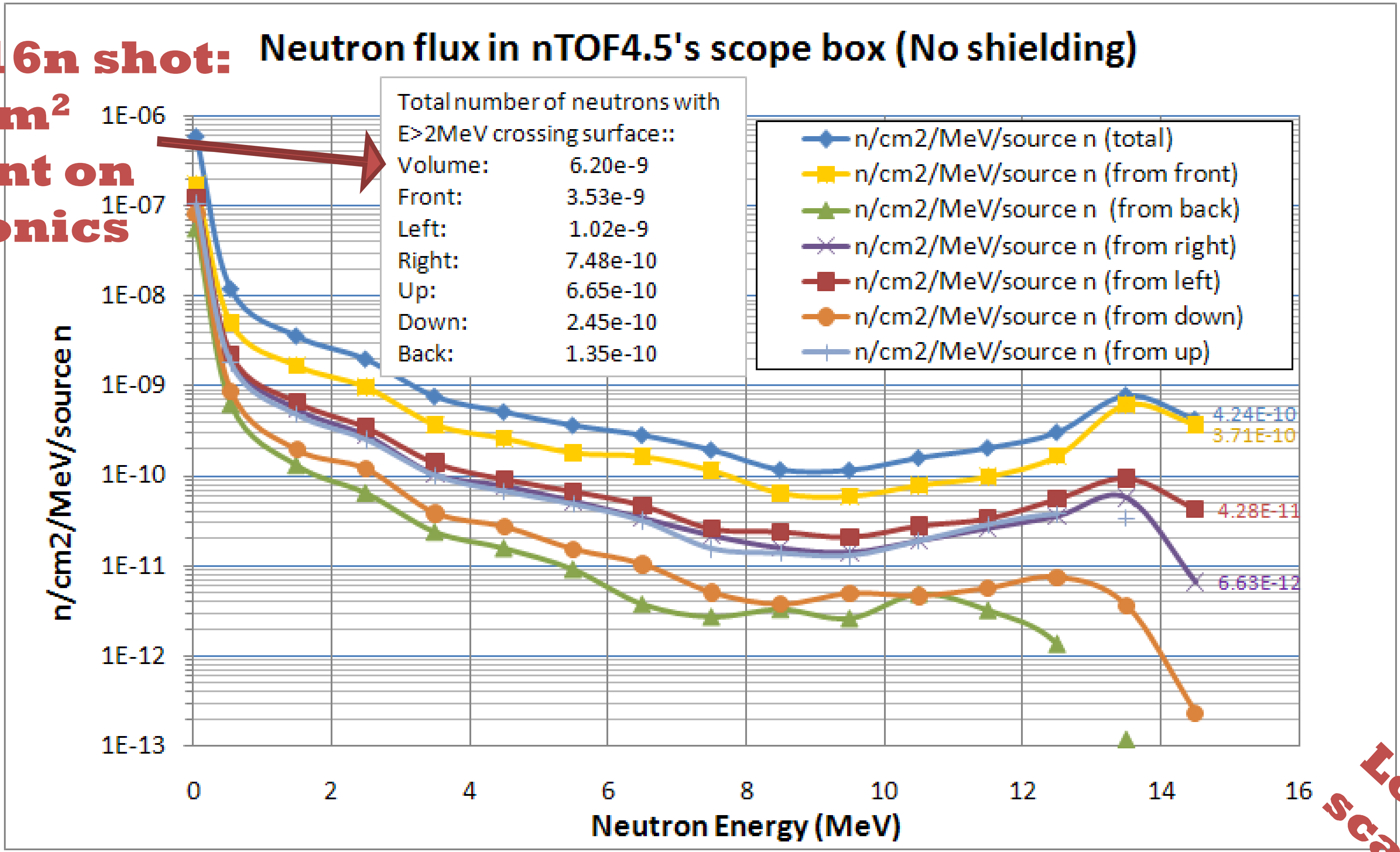


Simulation of the radiation background



Results w/o concrete: neutrons flux in box with angular distribution

For 1e16n shot: 6e7n/cm² incident on electronics

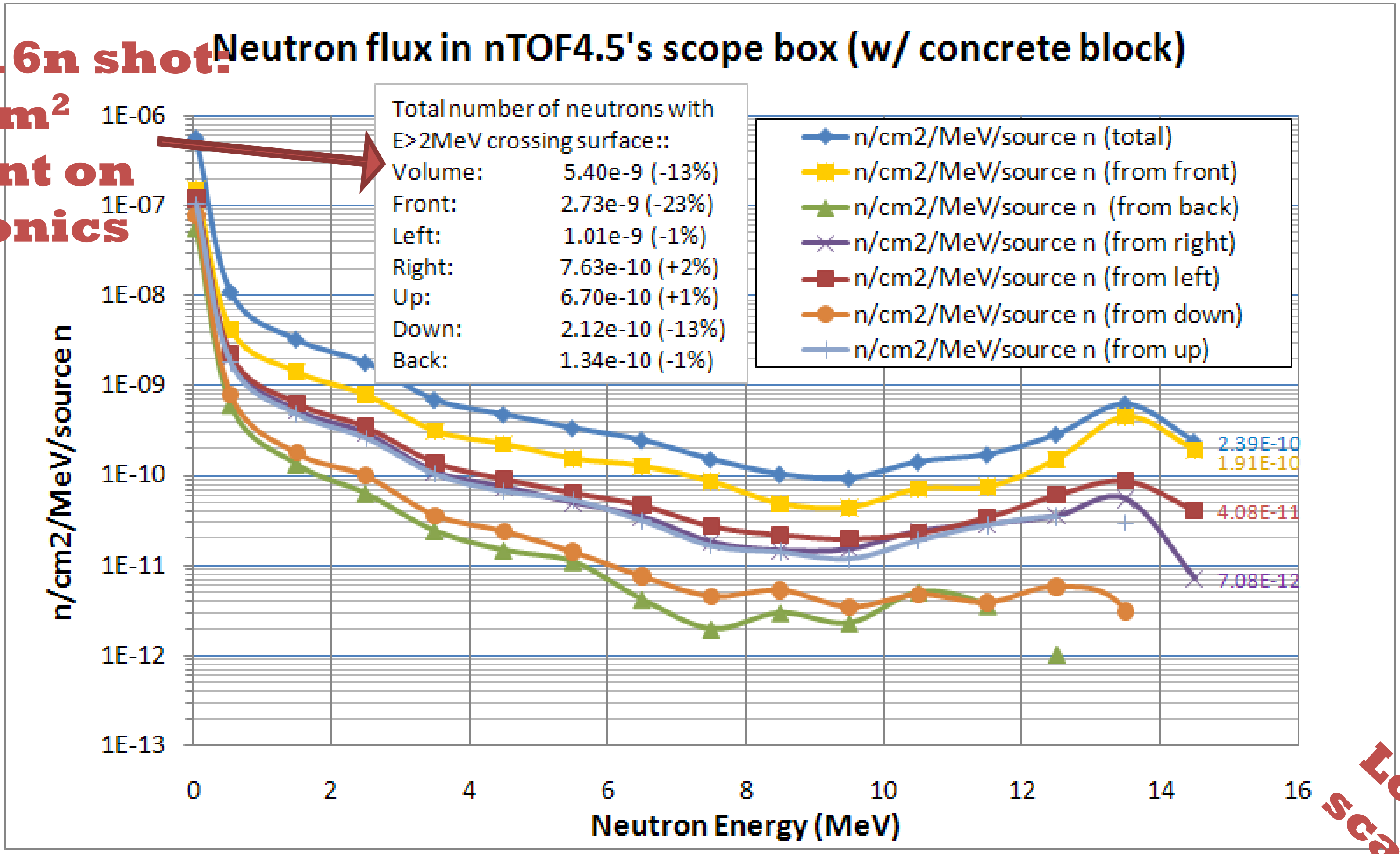


Lots of scattering!

- Number of neutrons crossing the front surface ≈ number of neutrons crossing sides and up surfaces
- The majority of neutrons with energies close to 14.1 MeV are not primary but are scattered with small angles

Results w/ concrete: neutrons flux in box with angular distribution

For 1e16n shot: 5e7n/cm² incident on electronics

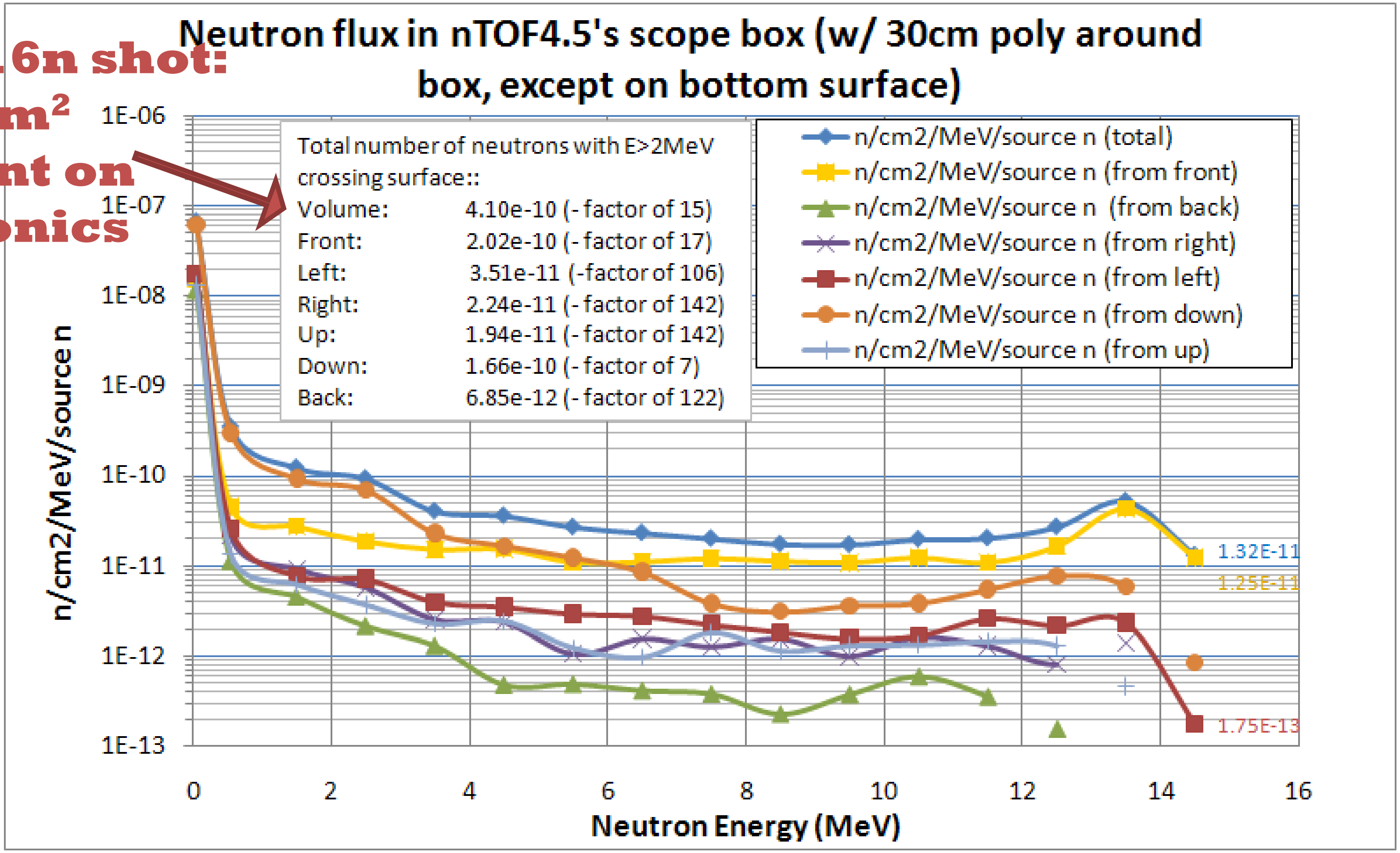


Lots of scattering!

- Concrete shield reduces only by 13% the number of neutrons
- Rule of thumb: factor of 10 reduction per foot of concrete → should be 10^4 in this case!!

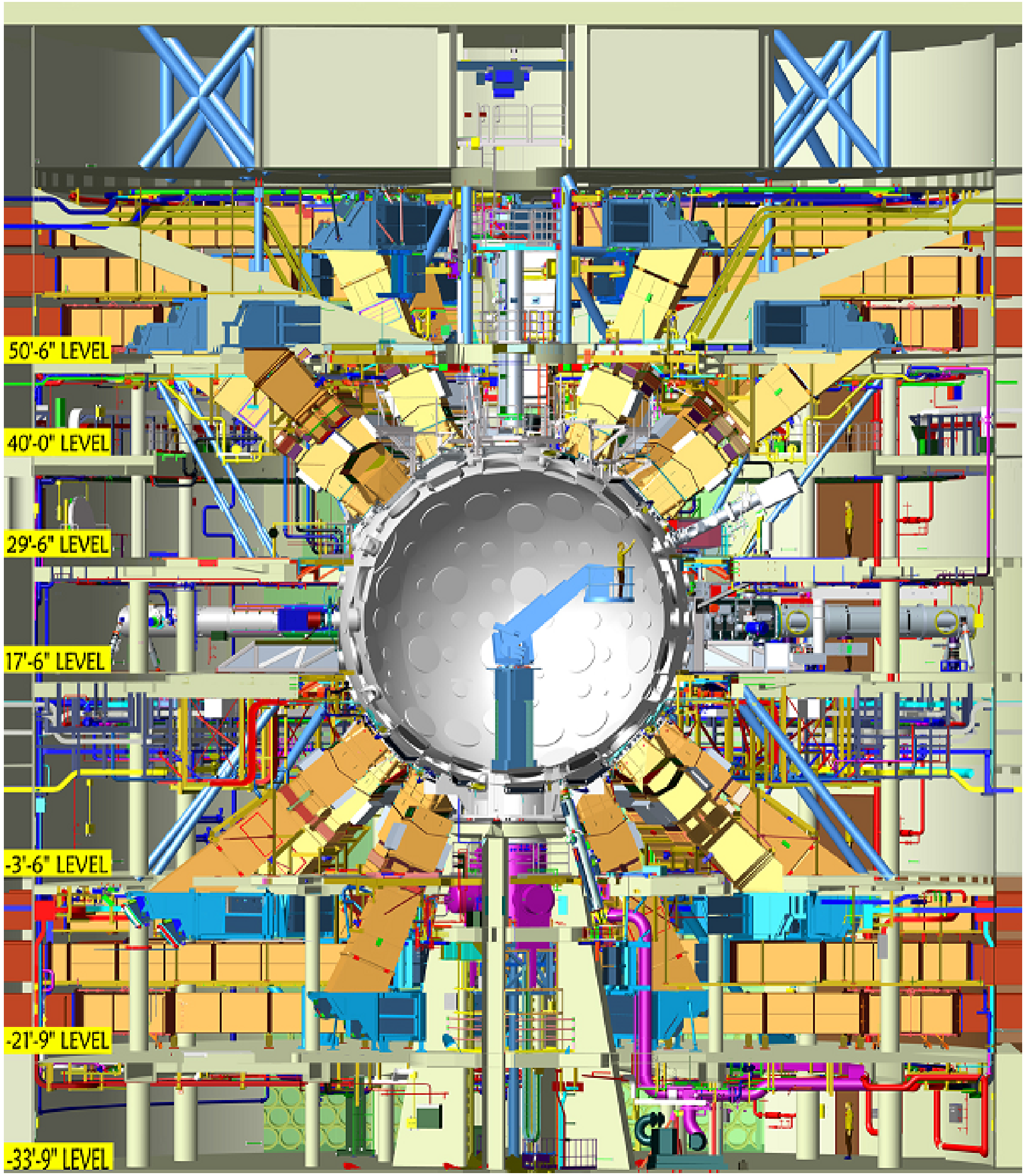
Results w/ 30cm poly: neutrons flux in box with angular distribution

For 1e16n shot: 4e6n/cm² incident on electronics



- n with E > 2 MeV: decrease by 15
- n with E ≈ 14 MeV: decrease by 30
- Better shielding: add polyethylene on bottom side

Conclusion



- The NIF environment is very complex leading to a large and non trivial radiation background.
- A shield surrounding the electronics is required to lower the neutron background to less than 1e7 n/cm^2.
- Moving electronics to behind the 6 foot-thick target bay wall is the best shield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